Properties of GENESYS™ Biocomposite Material Compared to Pure Polylactide (PLA)

Purpose: To compare the bone in-growth of GENESYS biocomposite material (96L/4D PLA copolymer mixed with β-TCP micro-particles) with pure PLA in a long-term rabbit bone model. **Methods:** Fifty-four implants were inserted into the femoral epiphyses of 27 rabbits. A bone tunnel was drilled 6 mm in diameter and 8 mm in length. The implants were examined at 24, 48, and 76 week by micro CT and histologically analyzed by scanning electron microscopy (SEM) and light microscopy. Bone in-growth levels were measured at each timepoint. **Results:** Micro CT of the GENESYS biocomposite confirmed the bone in-growth with oriented bone trabeculae as early as 24 weeks. At 76 weeks, intimate contact with the bone was not maintained with the pure PLA, whereas the bone bridge trabeculae were maintained directly perpendicular to the surface of GENESYS implant and in contact with β -TCP particles. Higher magnification showed new bone growth into the sub-surface of the GENESYS biocomposite and major bone formation on the surface of the GENESYS biocomposite. **Conclusions:** Bone contact was no longer maintained for the pure PLA at 76 weeks, while bone contact, bone in-growth and mineralization were evident for the GENESYS biocomposite with specific peripheral bone architecture. The β -TCP micro-particles acted as a scaffold for bone in-growth, maintaining the bone bridge trabeculae perpendicular to the GENESYS implant surface.

The objective of this study was to compare the bone in-growth of GENESYS biocomposite material (96L/4D PLA copolymer mixed with β-TCP micro-particles) with pure PLA in a long-term rabbit bone model. The implants were examined by micro CT, scanning electron microscopy (SEM) and light microscopy at 24, 48 and 76 weeks. Bone in-growth and mineralization were evident for the GENESYS biocomposite associated with specific peripheral bone architecture. According to this study, the GENESYS material aids in the bone remodeling process, which provides long-term stability required for ligament fixation devices.

Devices such as interference screws, that provide osteosynthesis (uniting of bone), require a good balance of bone in-growth and mechanical stability. Calcium phosphate bioceramics are well known for their ability to enhance bone in-growth and for forming a bone bonding interface[1,2]. The advantage of a GENESYS biocomposite is to maintain initial mechanical properties during early bone in-growth and then establish long-term mechanical properties via bone in-growth.

Methods

Materials

The bioabsorbable polymer PLA was melt mixed with beta-tricalcium phosphate to make the GENESYS biocomposite material. Pure PLA implants were also used. The cylindrical implants (6mm diameter*8mm length) were machined for the *in vivo* study. The fabricated implants were sterilized by gamma irradiation..

Test Procedure

Altogether, 54 implants were implanted into the femoral epiphyses of 27 rabbits. Three groups of animals were randomly created for implantation times of 24, 48, and 76 weeks. A drilled bone tunnel 6 mm in diameter, and 8 mm in length (i.e., critical size defect[3]), was centered on the lateral femoral condyle. After 24, 48 and 76 weeks, the implants were examined by micro CT and histologically analyzed by using scanning electron microscopy (SEM) and light microscopy. In polarized light microscopy, the background and soft tissue appeared in magenta, bone with oriented collagen fiber appeared in yellow to blue, and the β-TCP particles in black (Figure 1, 2 and 3).

Results

After 24 weeks, polarized light microscopy showed newly-formed bone on the pure PLA and GENESYS biocomposite (Fig. 1 a,b). There was lamellar bone in-growth in both samples parallel to the surface. Bone bridge trabeculae were perpendicular to the surface. Evidence of bioabsorbtion was observed on the surface of the implant made of pure PLA (Fig. 1a). Signs of enhanced bone remodeling were shown by bone growth at the surface of the GENESYS biocomposite (Fig 1b). After 48 weeks, newly-formed bone was developed on the pure PLA and GENESYS biocomposite (Fig. 2a,b). There was bioabsorbtion in the PLA implant (Fig. 2a). Higher mineral content was demonstrated on the surface GENESYS implant indicating the contact of both lamellar bone and bone bridge trabeculae with GENESYS biocomposite (Fig. 2b). After 76 weeks, the pure PLA implant showed extensive bioabsorbtion in the entire implant with release of polymer particles (Fig. 3a). Intimate contact with the bone was not maintained with the pure PLA, whereas the bone bridge trabeculae were maintained directly perpendicular to the surface of GENESYS implant and in contact with beta-tricalcium phosphate particles (Fig. 3b).

Higher magnification of scanning electron micrograph showed new bone growth into the sub-surface the GENESYS biocomposite (Fig 4). Micro CT of the GENESYS biocomposite confirmed the bone in-growth in 3D with oriented bone trabeculae at 24 weeks. The bone in-growth appeared in the sub-surface of the GENESYS biocomposite at 76 weeks. In addition, major bone formation was observed on the surface of the GENESYS biocomposite (Fig. 5b).

Conclusions

No foreign body reaction was reported in any of the samples and no incident occurred during the 76 week follow-up period. Bone contact was no longer maintained for the pure PLA at 76 weeks, while bone contact, bone in-growth and mineralization were evident for the GENESYS biocomposite with specific peripheral bone architecture. The β -TCP micro-particles acted as a scaffold for bone in-growth, maintaining the bone bridge trabeculae perpendicular to the GENESYS implant surface. The GENESYS biocomposite was suitably bioabsorbable for osteosynthesis, providing long-term stability as a knee ligament fixation.

References

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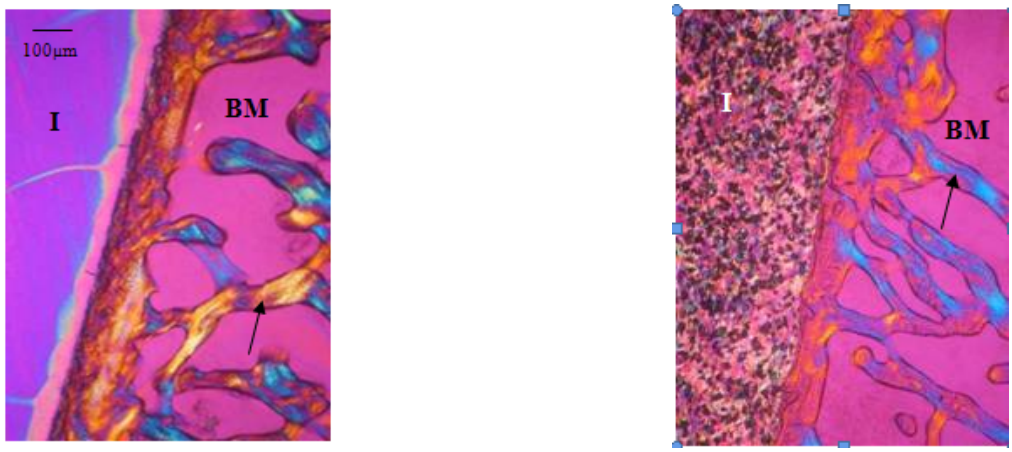
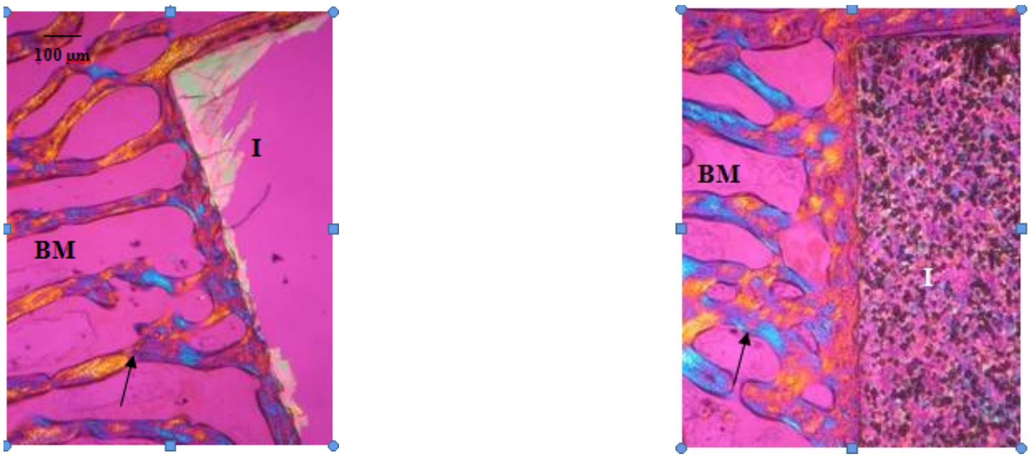


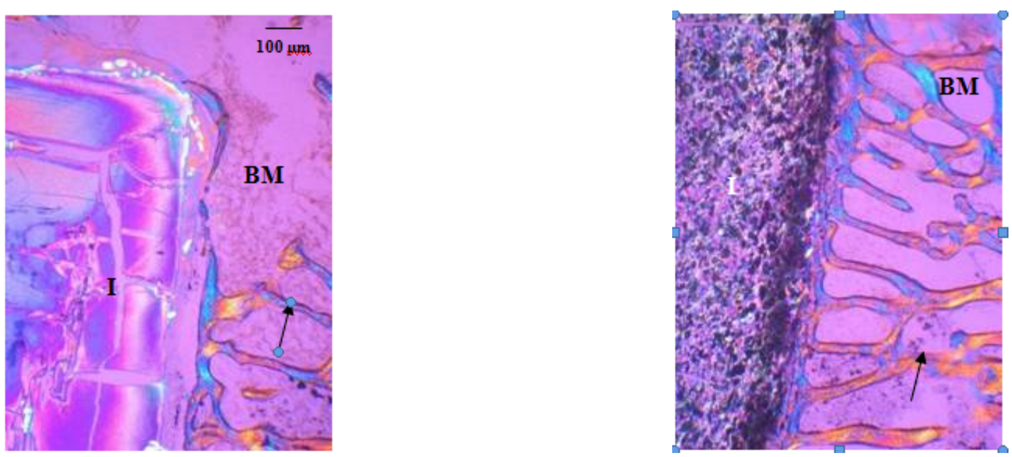
(a) (b)

Figure 1. *Polarized light micographs after 24 weeks on (a) pure PLA and (b) GENESYS.* ***I*** *is implant,* ***BM*** *bone marrow,* ***arrow*** *the new-formed bone and bone trabeculae.*



(a) (b)

Figure 2. *Polarized light micrographs after 48 weeks on (a) pure PLA and (b) GENESYS.* ***I*** *is implant,* ***BM*** *bone marrow,* ***arrow*** *the new-formed bone and bone trabeculae.*



(a) (b)

Figure 3. *Polarized light micrographs after 76 weeks on (a) pure PLA and (b) GENESYS.* ***I*** *is implant,* ***BM*** *bone marrow,* ***arrow*** *the new-formed bone and bone trabeculae.*

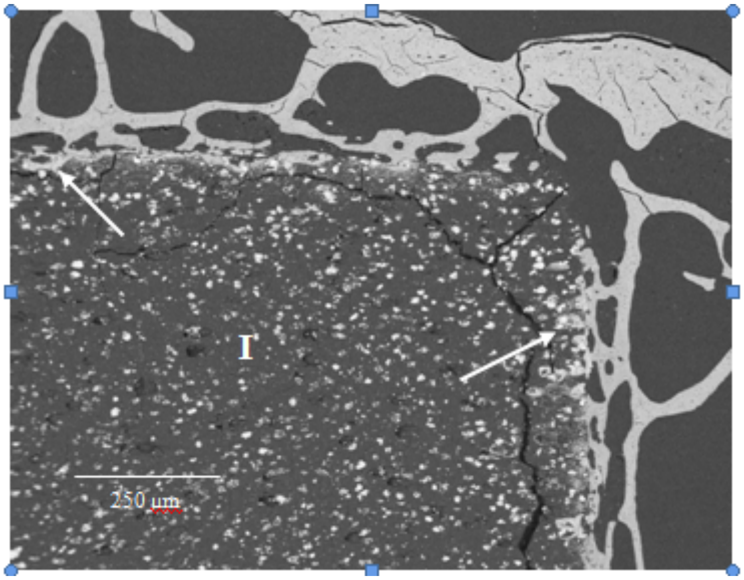


Figure 4. *Higher magnification scanning electron micrograph after 76 weeks of the interface between GENESYS and newly formed bone growing into the sub-surface of GENESYS (**arrow**), **I** is implant.*

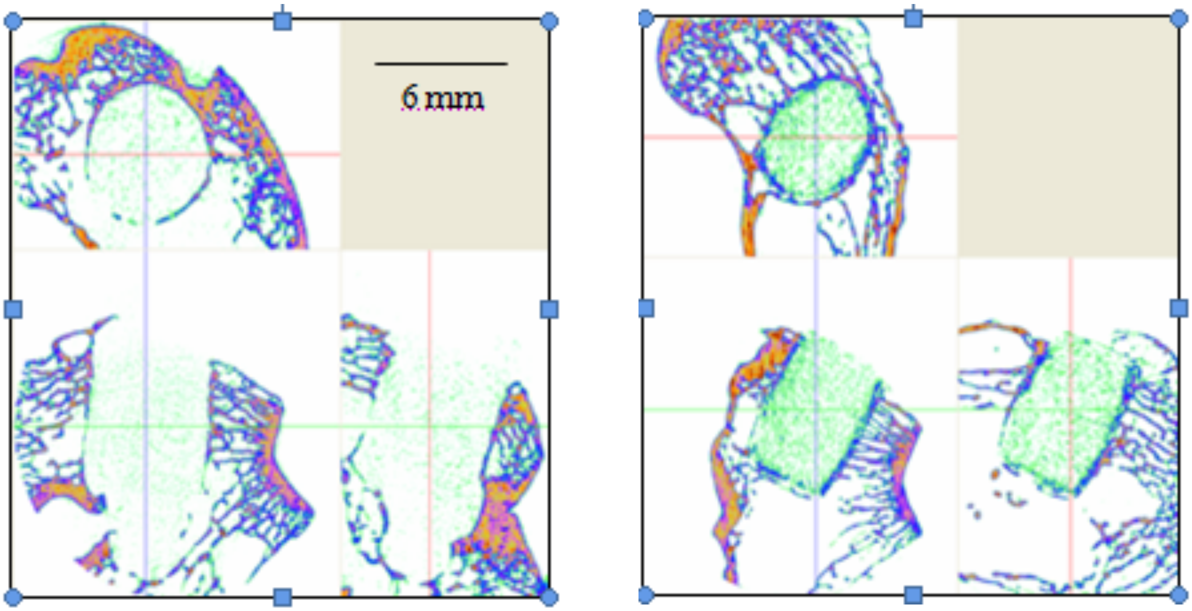


Figure 5. *Micro CT of (a) pure PLA and (b) GENESYS after 76 weeks of implantation.*